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August 30, 1993

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FEDERAL COMMUNICATIONS COMMISSION
OFFICE OF SECRETARY

HAND DELIVERY

William F. Caton
Federal Communications Commission
1919 M Street, N.W.
Room 222
Washington, D.C. 20554

Re: GEN Docket No. 90-314
ET Docket Nos. 92-9 and 92-100
Ex Parte Presentation

Dear Mr. Caton:

On August 24, 1993, pursuant to Section 1.1206 of the Commission's rules, we advised you of an August 19, 1993 meeting between Douglas Smith and Logan Scott, of Omnipoint Communications, Inc., and David Means and Phillip Inglis, of the Office of Engineering and Technology.

In connection with that meeting, the attached document entitled "Comments on WINForum Spectrum Etiquette" was subsequently delivered to Mr. Inglis.

In accordance with the Commission's rules, we are hereby submitting two copies of that document for each of the above-referenced proceedings.

Very truly yours,

Mark J. Tauber

cc: David Means
Phillip Inglis

No. of Copies rec'd 1
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Comments on Winforum Spectrum Etiquette

The Winforum spectrum etiquette is substantially incomplete. Under the current rules, isochronous and asynchronous systems will conflict strongly because of differences in their respective etiquette's and insufficient adjacent channel isolation.

Definitions of occupied bandwidth are wholly inadequate and will actually encourage poor spectral containment in signal design. Isochronous band, 1.25 MHz specific boundary channelization structures will promote inefficient spectrum utilization by precluding operation near the 1.25 MHz channelization boundaries wasting as much as 40% of the isochronous band. Specific narrowband systems are given tremendous advantages and even exceptions to the rules imposed on other systems. Perhaps most importantly, the Wintech approach forever rules out the benefits of systems which combine voice, data, and digitized image and video transmissions into one 5 MHz RF channel.

This document identifies and quantifies some of the more problematic issues Omnipoint has with the Winforum etiquette proposal and makes specific recommendations on how to modify the etiquette. Specifically, we recommend specifying a maximum isochronous band width of 5 MHz, allow any center frequency to be used over the isochronous frequencies, use power spectral density to limit power, modify the etiquette to allow handoff, and eliminate the bias which currently would cause asynchronous systems to knock isochronous systems off the air.

We continue to strongly encourage development of a spectrum etiquette by an open forum, ANSI accredited standards setting organization rather than an industry lobbying group such as Winforum.

Finally, we note that Winforum's proposed spectral etiquette is predicated on a 20 MHz total allocation for unlicensed services.

> *"In the end, the limitations imposed by the available spectrum to a large extent dictated the choice of the sub-banding"*[0]

Thus, if more than 20 MHz is allocated to unlicensed uses it is clear that even Winforum would not lobby for their overly restrictive and discriminatory proposal. With this said, we now will restrict ourselves to purely technical issues.

FCC Should Allow Up to 5 MHz Bandwidth in Isochronous Band

Winforum, has introduced the notion of channelizing the isochronous band into 1.25 MHz slices; ostensibly to make sure everyone gets a piece. Examination of any of the major spectrum requirements studies, including Winforum's own shows that significantly more than 1.25 MHz of spectrum is needed to provide adequate service in any dense urban "isochronous" application. Table 1, based on having 1 user per 100 m^2 (1076 $feet^2$) shows spectrum requirements of 3.6 MHz with 2% market penetration and almost 10 MHz with 30% market penetration.

Table 1: Spectrum Requirements Estimate In Small Cell Configuration (25 meter)

Users	Area (met^2)	Traffic per User (Erlangs)	Hexgrid Antenna Spacing (met)	Bandwidth per Channel (khz)	Frequency Reuse Factor (N)	Required Spectrum (MHz)
0.02	10.00	0.183	25	100	12	3.60
0.10	10.00	0.183	25	100	12	6.00
0.30	10.00	0.183	25	100	12	9.60

1% GOS, Erlang_B, Single Operator

[0]Comments on the Spectrum Etiquette, Winforum, page 5, submitted to the FCC 21 June 1993

Table 2 shows spectrum requirements with a larger cell spacing of 60 meters. Here, as much as 32 MHz of spectrum may be needed, simply to provide voice services.

Table 2: Spectrum Requirements Estimate In Medium Cell Configuration (60 meter)

Users	Area (met^2)	Traffic per User (Erlangs)	Hexgrid Antenna Spacing (met)	Bandwidth per Channel (khz)	Frequency Reuse Factor (N)	Required Spectrum (MHz)
0.02	10.00	0.183	60	100	12	6.00
0.10	10.00	0.183	60	100	12	14.40
0.30	10.00	0.183	60	100	12	32.40

1% GOS, Erlang_B, Single Operator

Clearly, some form of bandwidth aggregation procedure will be needed in the isochronous bands. In fact, the most recent "edits" proposed by the CT2 proponents would allow CT2 systems to aggregate to almost 4 MHz, which would be transmitting continuously, yet the current 1.25 MHz channelization proposed by Winforum excludes Omnipoint's 5 MHz alternative (as well as several others) which is TDMAed, and thus only transmitting a fraction of the time. Given the need for more than 1.25 MHz total spectrum per system anyway, we would propose that the FCC eliminate the 1.25 MHz channelization boundry structure proposed by Winforum since it is wasteful of spectrum.

Specifically, Winforum's boundry channelization scheme throws away significant amounts of spectrum by precluding operation near the 1.25 MHz boundaries. As ones RF center frequency closes in on the boundary, it becomes increasingly difficult to meet the adjacent channel requirements of paragraph 2.3.1 in the Winforum etiquette. Rather than throw away this spectrum, we would suggest eliminating isochronous sub-band boundary channelization entirely.

Omnipoint's seven years of experience with actual unlicensed operation in the ISM bands has taught us and all the other Part 15 vendors that real sharing occurs when different systems can choose any frequency so as to be able to "hide" in the nulls of other systems.

5 MHz Channels Will Provide Enormous Consumer Benefits

By allowing up to 5 MHz "isochronous" channels such as Omnipoint's, the consumer benefits of aggregation can be achieved at much lower costs without reducing the benefits of a spectrum etiquette. With even one 5 MHz RF channel, a base station can be installed which provides voice, packet data, ISDN data rates, JPEG and MPEG video standards, and data broadcast all from one low cost RF channel card. In contrast an etiquette which limits the unlicensed band to having to use multiple narrowband RF channels to deliver the same benefits means that the consumer will be required to pay for multiple RF cards and their associated coordination and filtering costs. Moreover, because Omnipoint's system uses TDMA within the 5 MHz, the interference generated in the band is no more than aggregated narrowband TDMA systems and is less than aggregated narrowband FDMA systems.

Definition of Occupied Bandwidth Encourages Poor Spectral Containment

> *"Occupied bandwidth is that bandwidth that contains 99% of the total transmit power, including allowance for frequency instability and spurious emissions."*[1]

In figure 1, we consider two possible modulation formats, unfiltered BPSK and MSK. Plotting Power Spectral Density (PSD) against normalized frequency for equal data rates, (T_b is bit duration) we observe the higher spectral sidelobe levels of the BPSK signaling format. 99% bandwidth is also indicated; the BPSK signal has a factor of 8.4 wider occupied bandwidth. Consequently, the BPSK signal is allowed a factor of 2.9 higher transmit power. At the receive end, only the central spectral lobe is of any importance; the rest of the transmitted energy will likely be filtered out to reduce susceptibility to interference. By using a signal format (BPSK) with poor spectral containment a higher transmit power is allowed, thus encouraging poor utilization of the spectrum. One might

[1]paragraph 3.1, Winforum spectrum etiquette of 21 June, 1993

argue that the use of poorly contained waveforms is self defeating because it limits one's own use of spectrum. This is not necessarily true; as an example, FSK formats with large mark/space frequency separation will have very large occupied bandwidths while maintaining narrow receive bandwidths. By frequency offsetting mark/space pairs, an FDMA system can be formulated with relatively high transmit powers. It will knock everyone else off the air in the local area.

Finally, the question of Frequency Hopping (FH) air interfaces is not adequately addressed in the Winforum definition of occupied bandwidth. Using synchronized, orthogonal hopping sequences FH systems become formidable opponents because they are allowed high power and step all over their occupied bandwidth with high instantaneous power spectral density. Indeed, it is hard to imagine how frequency hoppers could be tolerated at all in their band, yet there is no specific prohibition of them.

To address these issues, Omnipoint proposes that occupied bandwidth be defined in terms of receiver equivalent noise bandwidth. Specifications for spectral sidelobe levels can then be written in terms of " x dB down, measured y occupied bandwidths from center frequency". This will encourage the equipment manufacturer to use what he transmits and not just filter out the spectral sidelobes.

Alternatively, a scalable spectral mask could be used with maximum and minimum normalized PSD requirements. The minimum PSD requirement will serve to eliminate spectral holes such as those associated with the far FSK example. Either one of these approaches will mandate good spectral confinement.

Power Spectral Density Should Be The Primary Power Limit Criteria

The second element of Omnipoint's proposal is to eliminate occupied bandwidth as a criteria in setting transmit power. Instead, a maximum power spectral density in any 30 kHz bandwidth should be used (1 mW / 30 kHz is our specific recommendation). Because interference potential between systems is mostly determined by power spectral density within the victim receiver bandwidth this promotes greater fairness in spectrum

utilization. Wider bandwidth systems are allowed greater transmit power but because of their larger receive bandwidth, they become bigger targets.

Winforum Protocol Strongly Favors Narrowband FDMA In the Isochronous Band

Winforum has not presented data to the FCC showing the interaction between different bandwidth systems. Specifically we need to ask how the Winforum etiquette affects contention for the same spectrum; i.e. which system actually gains access. Figure 2 considers this question by defining two hypothetical systems using idealized "boxcar" spectrum shapes. The wideband system uses a single, 1 MHz wide RF carrier with a TDMA access protocol and 100 mWatt transmit power. The narrowband system uses an FDMA access protocol with multiple 50 kHz wide carriers, each transmitting with a power of 22.4 mWatts. Up to 20 narrowband carriers can be active within the wideband system's frequency allocation.

Because of filtering, the narrowband system's receivers will see 50 kHz / 1 MHz = 1 / 20 of the wideband system's 100 mWatt of transmitted power, (5 mW). The wideband system will see N*22.4 mWatts of the narrowband system's power where N is the number of narrowband transmitters active. Using the 30 dB Listen Before Talk (LBT) threshold[2] rules defined in paragraph 5.4.2.1 of Winforum's etiquette, we obtain the results of figure 2.

Here, we plot relative exclusion area size as a function of the number of narrowband transmitters active for three different propagation cases[3]. A value of 200% means that the area over which the narrowband system excludes wideband system operation because of LBT rules is twice as large as the area over which the wideband system excludes narrowband operation.

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[2]Winforum is unclear on what they mean by "30 dB above the thermal noise power in the occupied bandwidth". We have interpreted this to mean 30 dB above the thermal noise measured out of an antenna with a 300K antenna temperature. Measurement bandwidth is the equivalent noise bandwidth in our example.

[3]$1/R^{1.5}$ propagation is commonly seen in the indoor environment when ducting conditions are presents. Examples include hallways, machine rooms, etc.

Except when very lightly loaded, the narrowband system is always the winner in contention situations because it is allowed to transmit with up to 4.5 times higher PSD[4] while accepting only 1/20th of the wideband system's transmit power (5 mWatt) into LBT threshold calculations. It would not be uncommon to have the wideband system shut down when the narrowband system gets loaded.

Only Narrowband Systems Are Given An Exception To "Talk Before Listen"

This is especially true if the FCC adopts the remainder of paragraph 5.4.2.1. Basically what this rules says is: If you have a narrowband FDMA system and you look around and can't find an open channel, go ahead and turn on any ways (unless someone is extremely nearby). Rules such as this should not be part of the etiquette since they specifically advantage particular system architecture's. Rather, generic rules should be developed that allow any system to perform a handoff by responding to a system trying to communicate with it.

Exacerbating the problem, Winforum specifications on LBT threshold accuracy appear too loose.

"The resolution for power measurements need not be more accurate than 6 dB"[5]

Figure 3 considers the case where the narrowband system has an LBT threshold of 36 dB; 6 dB higher than specified but still within tolerance. The narrowband system now totally dominates; even when lightly loaded. One possible solution to explore is to require tolerancing LBT thresholds as +0 db, -infinity dB. The only penalty for setting your LBT threshold too low is that your system can not turn on. Allowing for positive deviations only enhances a system's ability to turn on; at the expense of competing systems.

Finally, figure 4 shows the performance of our proposed etiquette modifications. Here, we combine our spectral density rule (1 mW/30 kHz as discussed in last section) with an LBT threshold that varies depending on occupied bandwidth. The narrowband system continues to have a substantial advantage when heavily loaded but no longer does it

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[4] 20 * 22.4 mWatts / 100 mWatts = 4.5

[5] paragraph 5.4.2.1 of Winforum etiquette.

have an advantage when it is less then 50% loaded. Narrowband systems using RF carriers with an occupied bandwidth of less than 100 kHz are allowed a higher LBT threshold of 33 dB (+0,-infinity dB) while wider bandwidth systems operate with an LBT threshold of 30 dB (+0,-infinity dB). This approach encourages the narrowband systems to exploit their comparative agility and seek other frequencies when lightly loaded. Under more heavily loaded conditions, Omnipoint's rules favor the incumbent system and tends to prevent a wideband system from turning on.

Asynchronous Systems Will Overpower Isochronous Systems Because of Protocol Differences

Ericsson has identified a serious incompatibility between the asynchronous and isochronous bands due to differences in Listen Before Talk (LBT) protocols. Unfortunately, the issue has been trivialized in it's representation to the TR46.3 standards bodies because Ericsson's analysis only considered a Isochronous to Asynchronous device separation of 16 inches.

Referring to figure 5[6], isochronous systems must monitor for a full 10 msec prior to commencement of transmissions. Asynchronous devices need only look for about 30 usec; they may entirely miss the presence of an adjacent (or near adjacent) channel isochronous device. The isochronous device may try to change time slots in response but because of the unpredictable nature of the asynchronous device it is likely to start thrashing and ultimately drop the call.

Referring to figure 6, Omnipoint has performed an analysis to consider the effects of other Async/Isoch device spacings. In this analysis, the asynchronous and isochronous systems both have a 1 MHz occupied bandwidth, transmit equal peak powers of 100 mWatt, and require a 14 dB S/(I+N) ratio for successful operation. We consider three cases for adjacent channel isolation in accordance with the Winforum etiquette proposal (paragraph 2.3.2); 30 dB for first adjacent, 50 dB for second adjacent; and 60 dB for subsequent adjacent channels. The "y" access shows reduction in isochronous coverage area as a function of how close the asynchronous device is compared to the "no async"

[6]From Ericsson June 4 1993 filing on PCS NPRM Etiquette.

case. A breakpoint propagation model was used as shown in figure 7 to more accurately model the more rapid signal strength fall off rate at further ranges.

Returning to figure 6, we note that even with a device separation of 100', the isochronous coverage area is only 8% of what it would have been if only 30 dB of adjacent channel isolation is provided. Increasing isolation helps but it is clear that the async devices have a decided advantage when two systems are operating in the same room.

As a first recommendation to the FCC, we would suggest tightening the "out-of-subband" emissions limit to 50 dB in the first adjacent channel and 60 db in subsequent channels. Secondly, we would suggest that asynchronous devices be required to listen for at least 20 msec prior to their first transmission in order to obtain a time history of nearby isochronous transmissions. A 20 msec listening interval is needed to allow for a duplex frame interchange by the isochronous device. This will mark both the transmit and receive time slots to the asynchronous device,thereby aiding in coexistence.

Summary Recommendations

- Allow for any bandwidth up to 5 MHz RF channel bandwidth.
- Eliminate specific 1.25 MHz boundaries proposed in isochronous band since they waste up to 40% of the isochronous spectrum unnecessarily.
- Make interference measurement equitable for all systems by using Power Spectral Density: Allow 1 mWatt/30 kHz.
- Power Spectral Density: Allow 1 mWatt/30 kHz.
- Eliminate bandwidth dependent peak transmit power limit.
- Make isochronous LBT threshold 33 dB for BW$\leq$100 kHz, 30 dB otherwise.
- Raise wall between Asynchronous subband and Isochronous subband to 50 dB.
- Add 20 msec "first time only" LBT protocol to asynchronous requirements.
- Allow completion of spectrum etiquette in ANSI approved standards body.

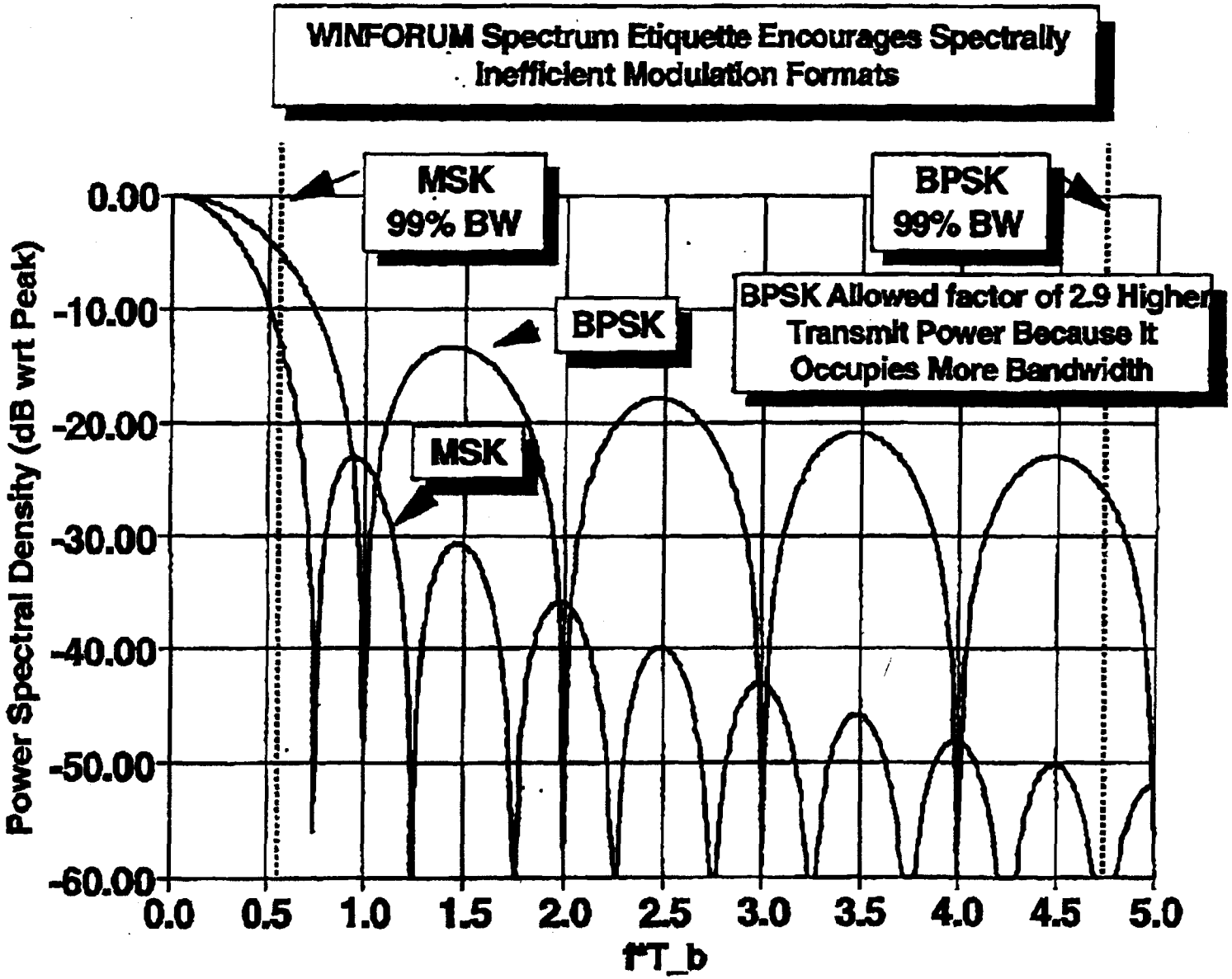

WINFORUM Spectrum Etiquette Encourages Spectrally Inefficient Modulation Formats
MSK 99% BW
BPSK 99% BW
BPSK Allowed factor of 2.9 Higher Transmit Power Because It Occupies More Bandwidth
BPSK
MSK
Power Spectral Density (dB wrt Peak)
0.00
-10.00
-20.00
-30.00
-40.00
-50.00
-60.00
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
f*T_b

Figure 1

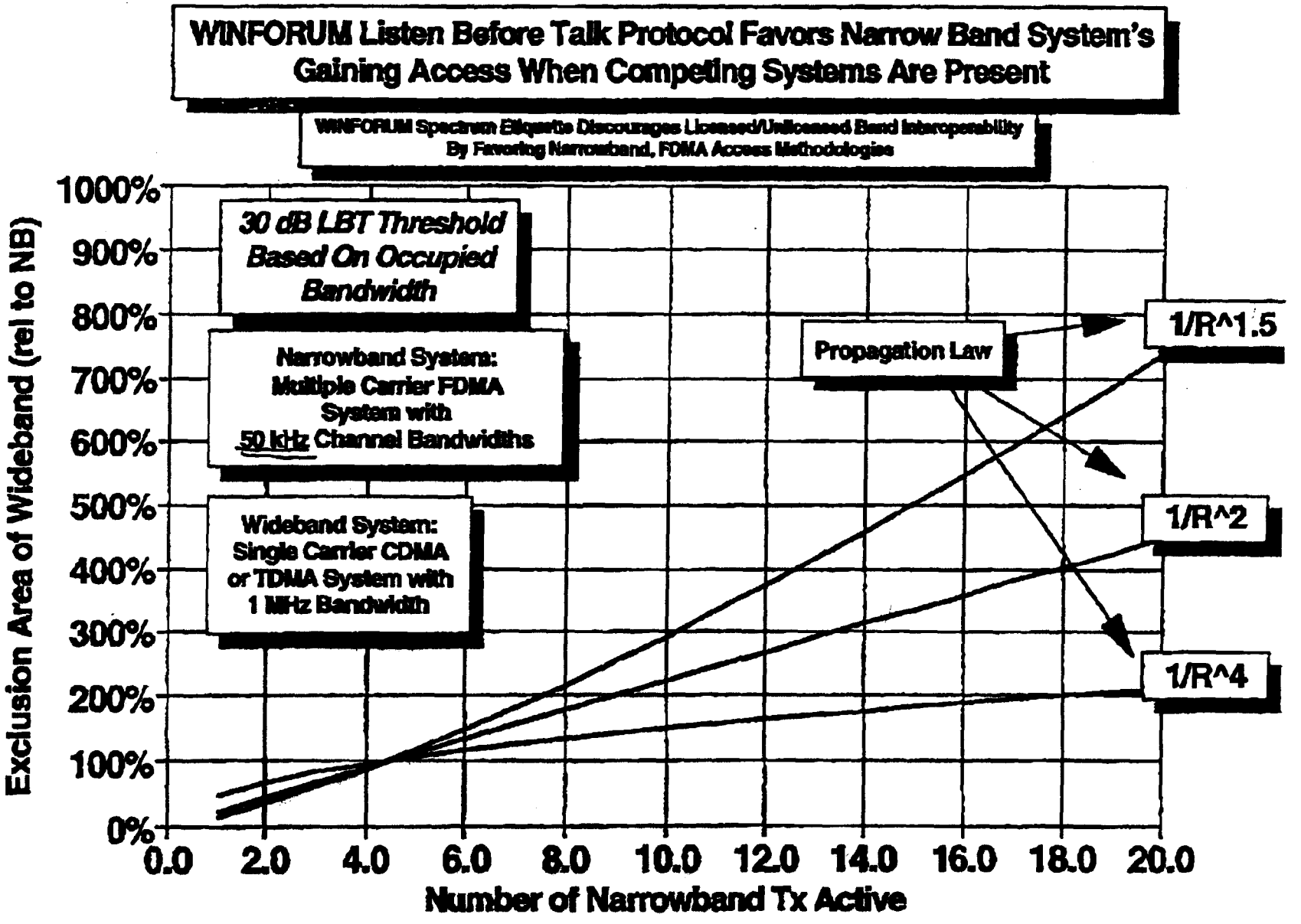

WINFORUM Listen Before Talk Protocol Favors Narrow Band System's Gaining Access When Competing Systems Are Present
WINFORUM Spectrum Etiquette Discourages Licensed/Unlicensed Band Interoperability By Favoring Narrowband, FDMA Access Methodologies
30 dB LBT Threshold Based On Occupied Bandwidth
Narrowband System: Multiple Carrier FDMA System with 50 kHz Channel Bandwidths
Wideband System: Single Carrier CDMA or TDMA System with 1 MHz Bandwidth
Propagation Law
1/R^1.5
1/R^2
1/R^4
Exclusion Area of Wideband (rel to NB)
1000%
900%
800%
700%
600%
500%
400%
300%
200%
100%
0%
0.0
2.0
4.0
6.0
8.0
10.0
12.0
14.0
16.0
18.0
20.0
Number of Narrowband Tx Active

Figure 2

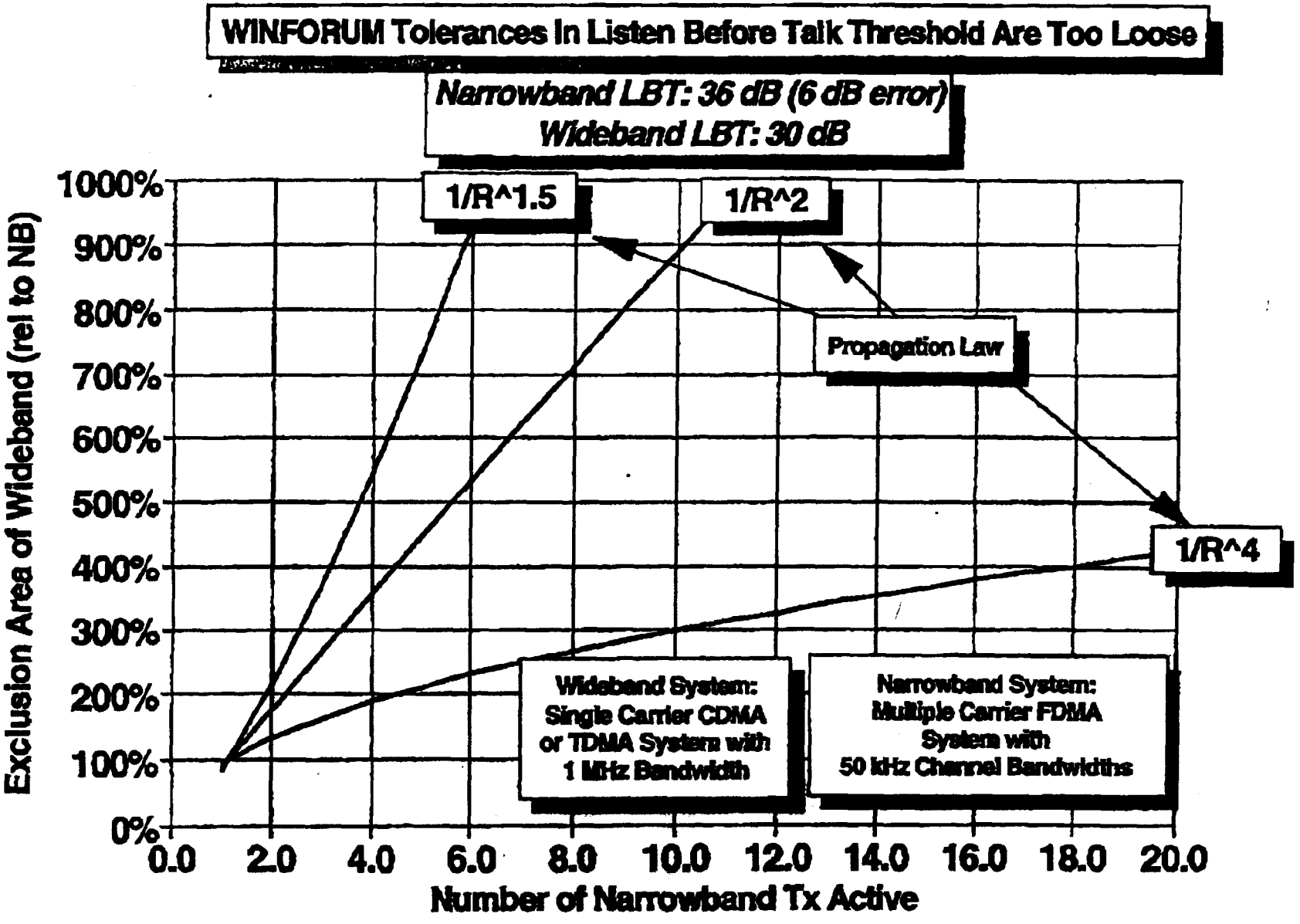

WINFORUM Tolerances In Listen Before Talk Threshold Are Too Loose
Narrowband LBT: 36 dB (6 dB error)
Wideband LBT: 30 dB
1/R^1.5
1/R^2
Propagation Law
1/R^4
Wideband System: Single Carrier CDMA or TDMA System with 1 MHz Bandwidth
Narrowband System: Multiple Carrier FDMA System with 50 kHz Channel Bandwidths
Exclusion Area of Wideband (rel to NB)
1000%
900%
800%
700%
600%
500%
400%
300%
200%
100%
0%
0.0
2.0
4.0
6.0
8.0
10.0
12.0
14.0
16.0
18.0
20.0
Number of Narrowband Tx Active

Figure 3

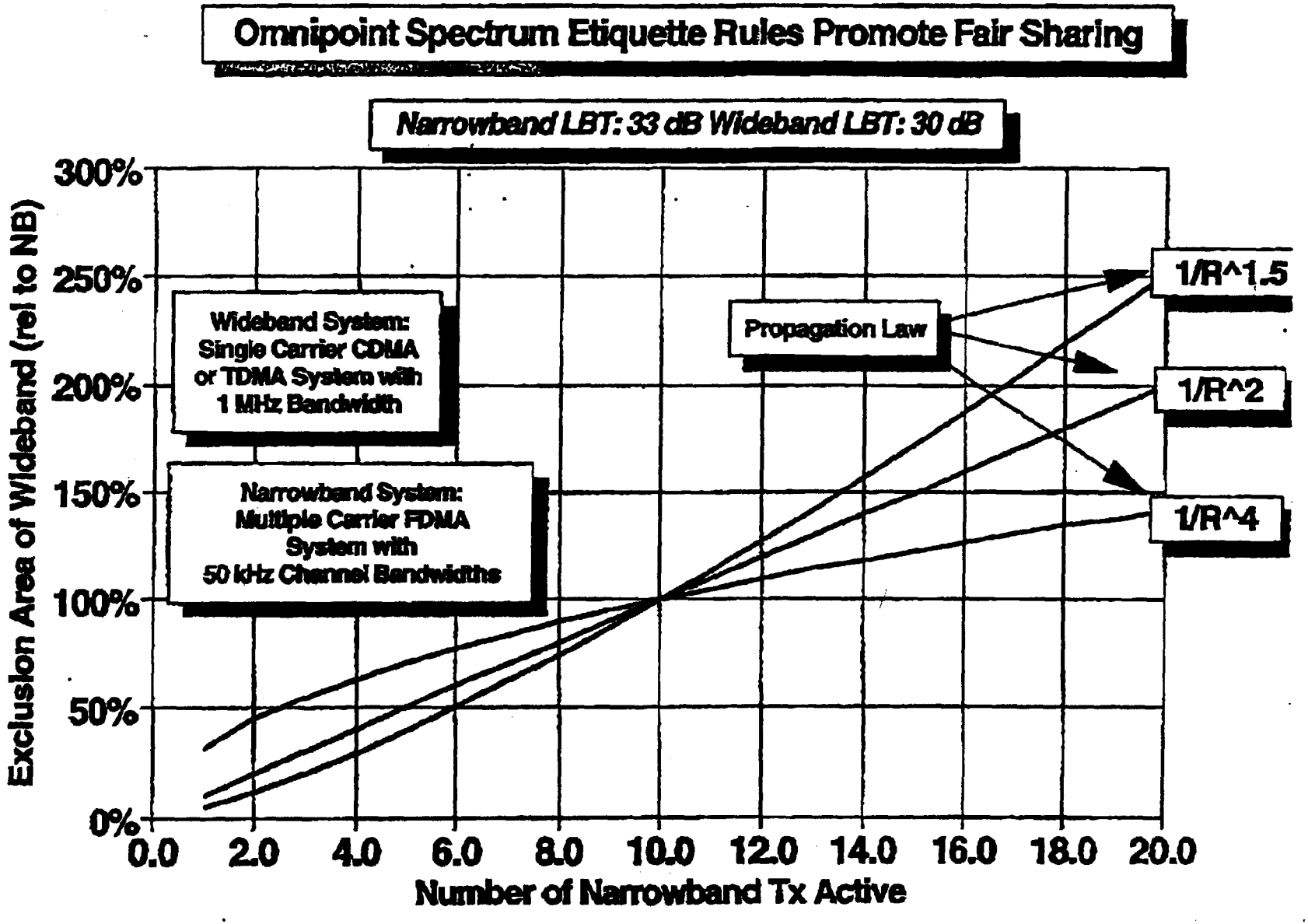
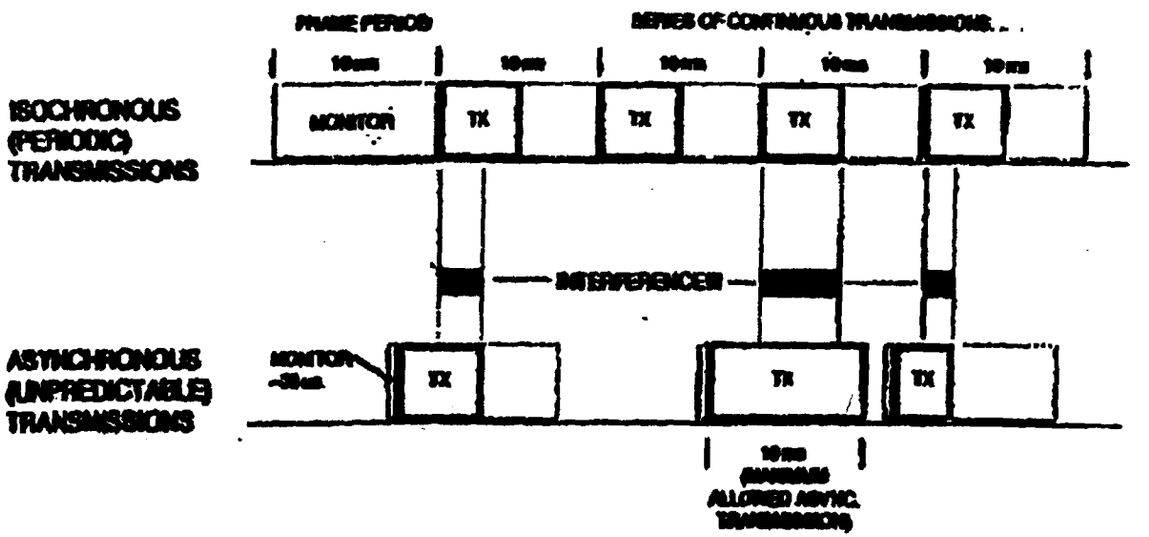

Omnipoint Spectrum Etiquette Rules Promote Fair Sharing
Narrowband LBT: 33 dB Wideband LBT: 30 dB
Exclusion Area of Wideband (rel to NB)
300%
250%
200%
150%
100%
50%
0%
0.0
2.0
4.0
6.0
8.0
10.0
12.0
14.0
16.0
18.0
20.0
Number of Narrowband Tx Active
Wideband System: Single Carrier CDMA or TDMA System with 1 MHz Bandwidth
Narrowband System: Multiple Carrier FDMA System with 50 kHz Channel Bandwidths
Propagation Law
1/R^1.5
1/R^2
1/R^4

Figure 4

REFERENCE

The WINForum Etiquette

THE INCOMPATIBILITY OF ASYNCHRONOUS AND ISOCHRONOUS RADIO TRANSMISSIONS



Since it is only obligated to "listen" for a few microseconds, an asynchronous device can DIRECTLY interfere with a periodically transmitting isochronous device.

FCS WINN Etiquette
June 4, 1993

Figure 5 (from Ericsson)

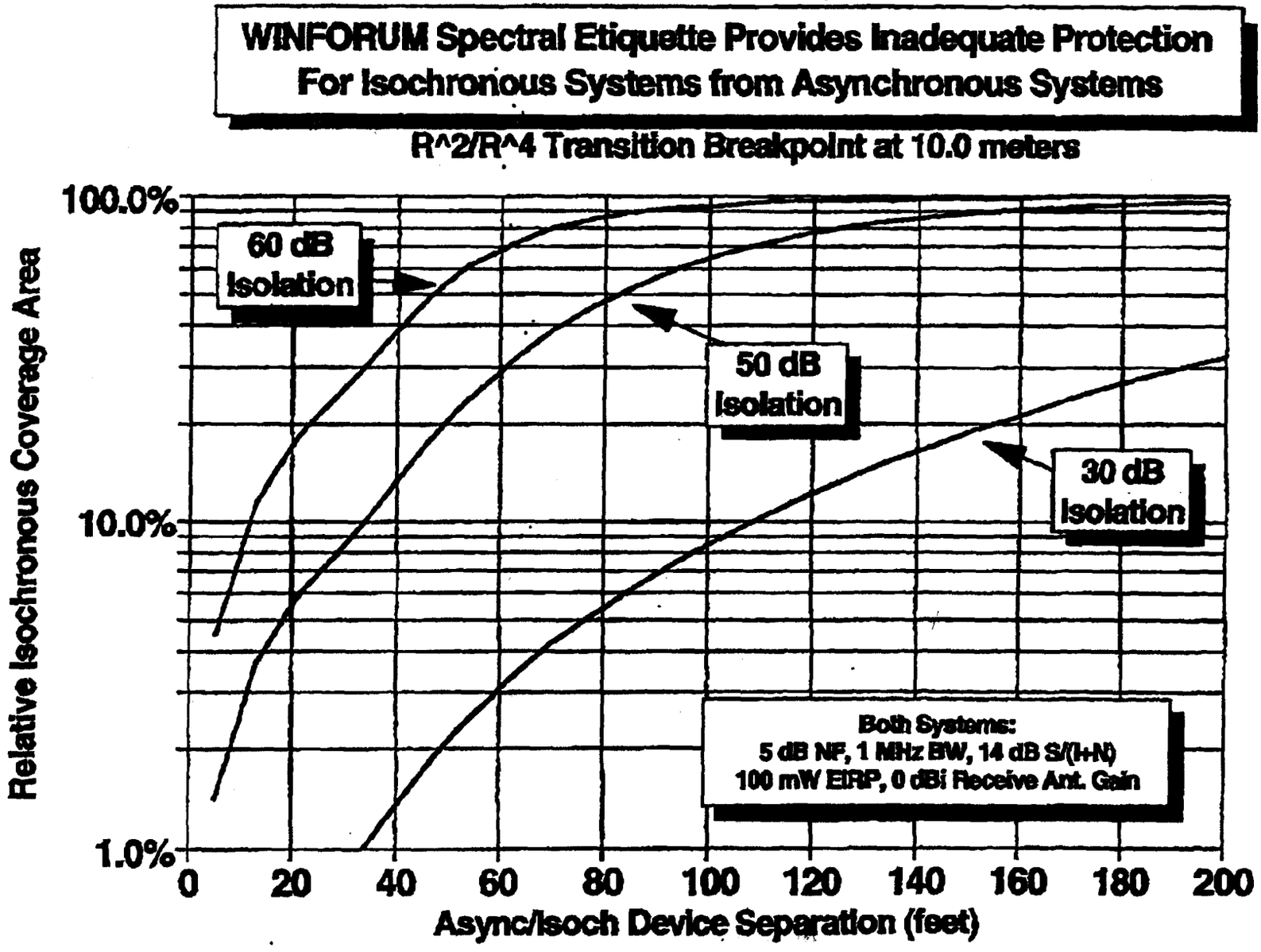

WINFORUM Spectral Etiquette Provides Inadequate Protection
For Isochronous Systems from Asynchronous Systems
R^2/R^4 Transition Breakpoint at 10.0 meters
100.0%
10.0%
1.0%
60 dB Isolation
50 dB Isolation
30 dB Isolation
Both Systems:
5 dB NF, 1 MHz BW, 14 dB S/(I+N)
100 mW EIRP, 0 dBi Receive Ant. Gain
Relative Isochronous Coverage Area
0
20
40
60
80
100
120
140
160
180
200
Async/Isoch Device Separation (feet)

Figure 6

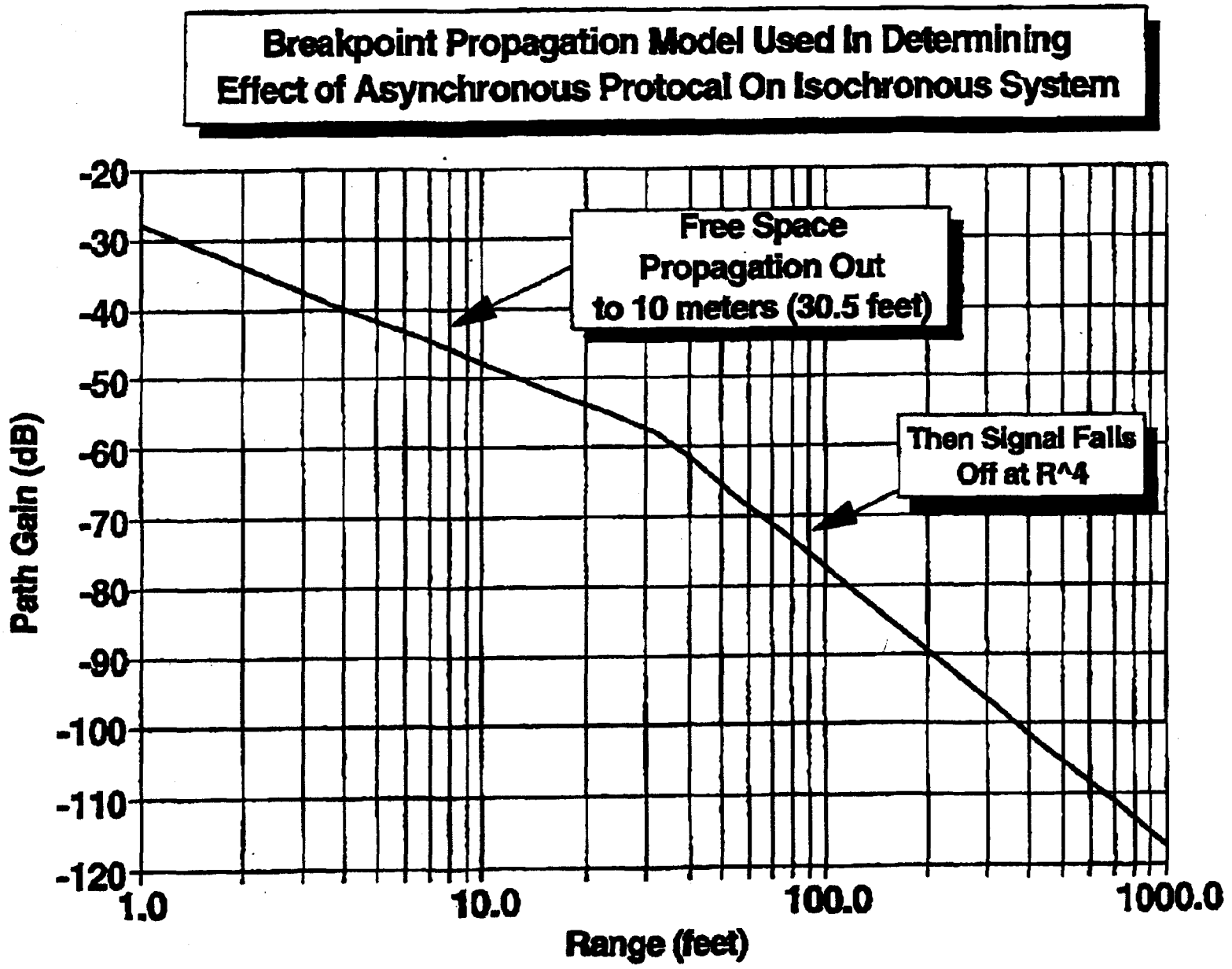

Breakpoint Propagation Model Used In Determining
Effect of Asynchronous Protocal On Isochronous System
Free Space
Propagation Out
to 10 meters (30.5 feet)
Then Signal Falls
Off at R^4
Path Gain (dB)
-20
-30
-40
-50
-60
-70
-80
-90
-100
-110
-120
1.0
10.0
100.0
1000.0
Range (feet)

Figure 7